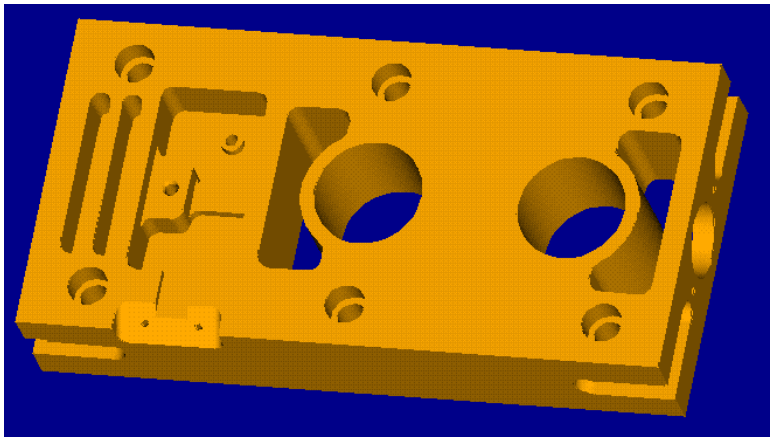
Process and Resource Simulations



What

- Determined critical workpiece features
- Calculated surface error
  - End milling of multi-step pocket
  - Face milling of top surface
- Predicted drill torque and thrust in metering hole

Why

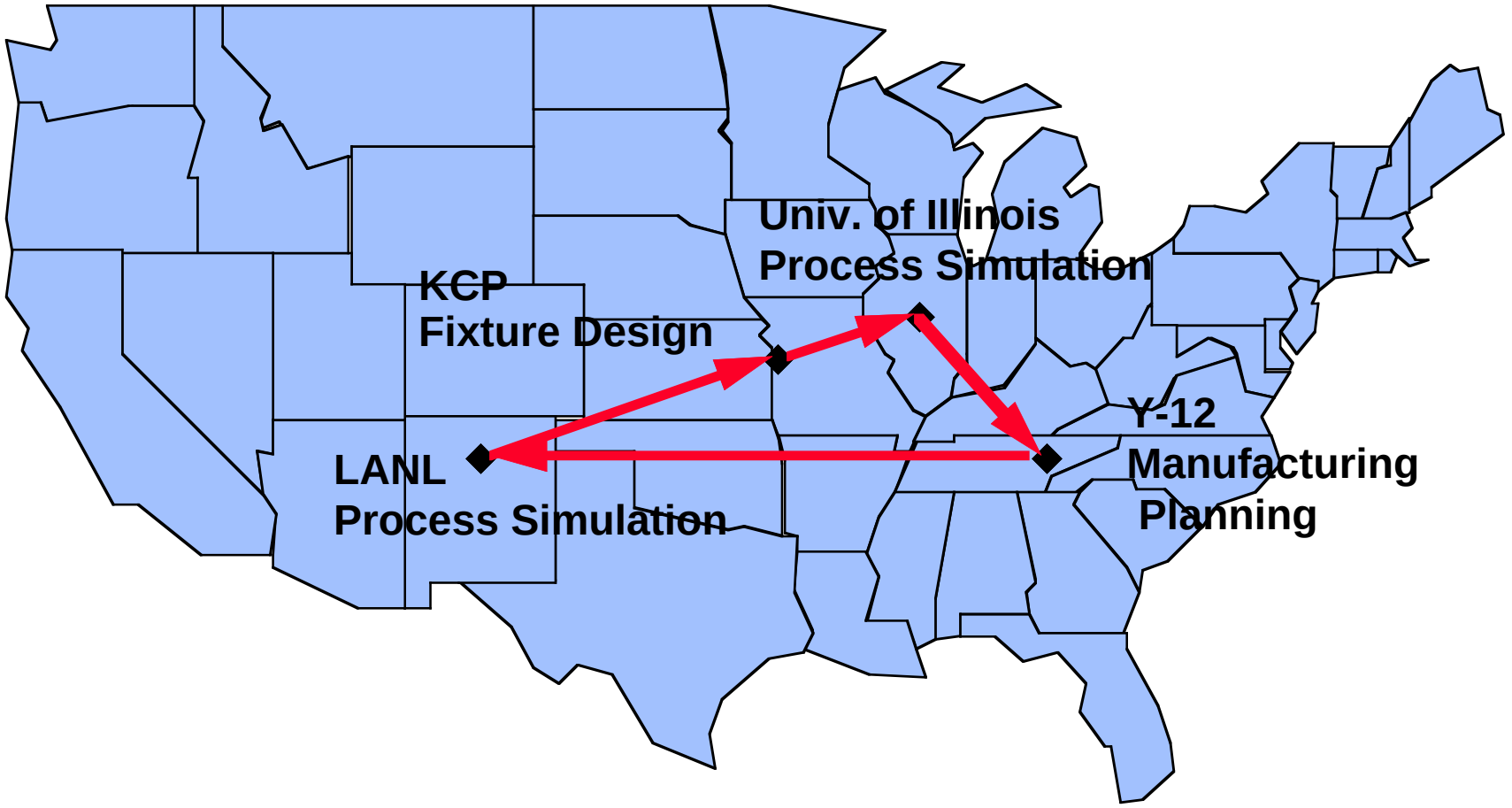
- Identify improvements to the process plan and fixture design before committing to the shop floor
- Reduce shop floor rework

How

- Performed simulations in a networked collaborative environment

“Manufacturing in a Computer”

Distributed Enterprise
Process and Resource Simulation

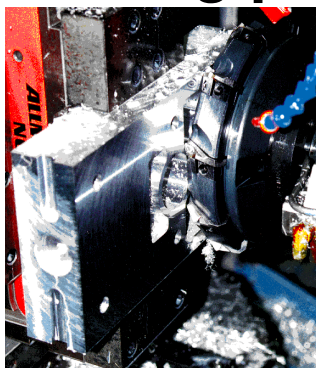


Material Removal Simulations

- Performance Analysis
  - Thermal Analysis (FEA) Mechanica
  - Stress Analysis (FEA) COSMOS
- Process Simulation
  - Dynamic Simulations Deform. Tool/Workpiece
    - Drilling/End Milling
      - Drilling DRSIM
      - End Milling EMSIM
    - Face Milling
      - Finite Element Mesh I-DEAS
      - FEA ABAQUS
      - Face Milling FMSIM
  - Kinematic Simulations Rigid Body
    - CMM Simulation CIMStation
    - Machining Simulation Virtual NC
- Enterprise Modeling Extend

Face Milling Simulations

- **Detailed analysis of surface error from finish face milling operation on top surface**
- **Investigate alternative manufacturing plans to reduce surface error**
  - **Fixture designs**
    - » **3-2-1 fixture design**
    - » **4-clamp fixture design**
  - **Process plans**

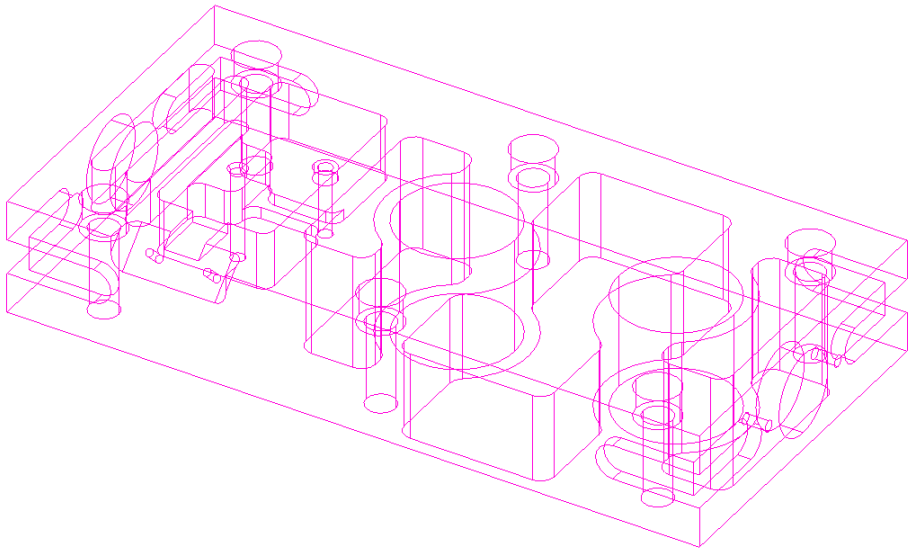


- **How**
  - **Generated 3-D IGES representation of part using ProEngineer**
  - **Developed 3-D finite element mesh with I-DEAS**
  - **Computed stiffness matrix and influence coefficients using ABAQUS**
  - **Calculated surface error due to workpiece deformation with FMSIM**
  - **Results used in Process and Resource Tradeoff**

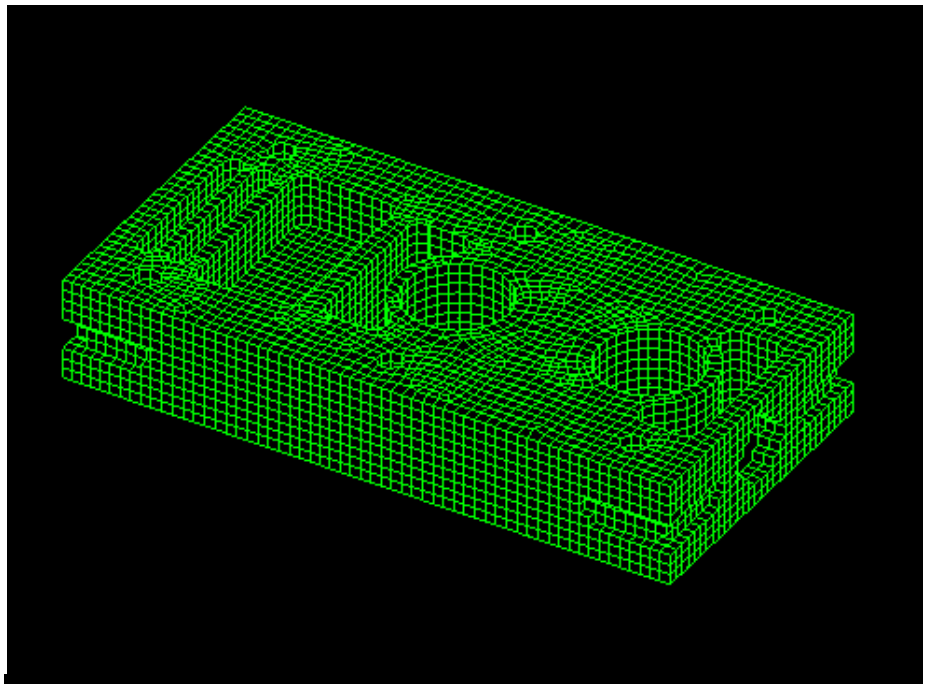
Process Simulations Reduce Shop Floor Rework

Face Milling Surface Error Calculation Process

3-D Wireframe IGES Representation from ProEngineer

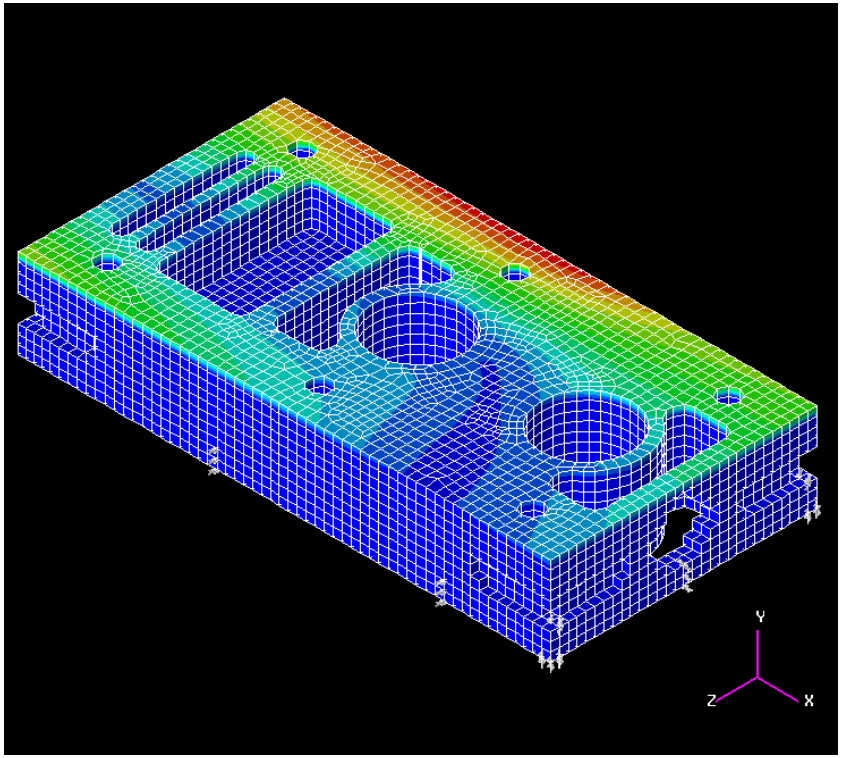


3-D Finite Element Mesh Developed with I-DEAS

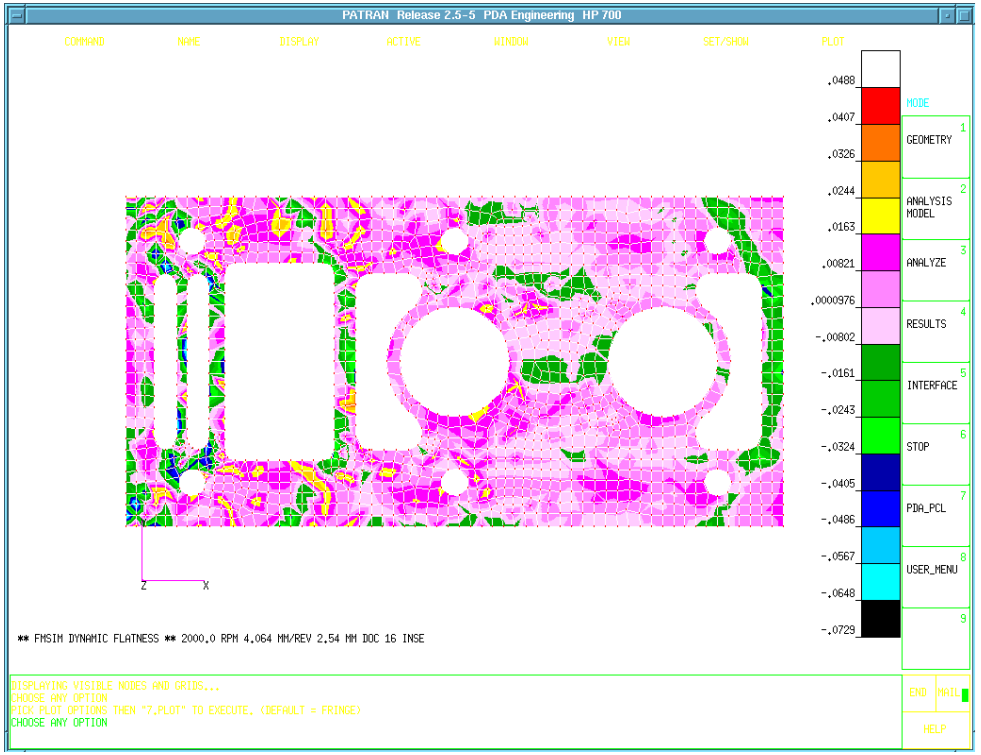


Face Milling Surface Error

Workpiece Displacement from ABAQUS



Surface Error Calculated with FMSIM

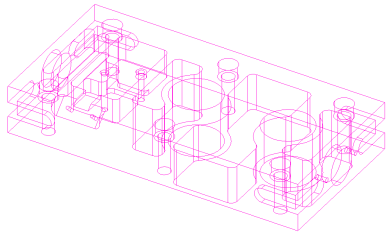


Improve Fixture Design and Process Plan Before Committing to the Shop Floor

FACE MILLING SIMULATIONS OF TEAM PART

Manufacturing Configurations

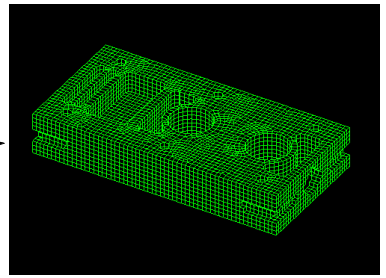
Workpiece Definition Pro/Engineer



3D IGES Wireframe

Fixture Designs

Mesh Development I-DEAS



Finite Element Mesh

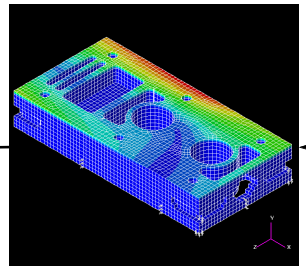
Finite Element Analysis ABAQUS

Stiffness Matrix and Influence Coefficients

Face Milling Simulation FMSIM

Process Plans

Modify Fixturing Configurations and Process Plans



Surface Error Contours

OK

No

Yes

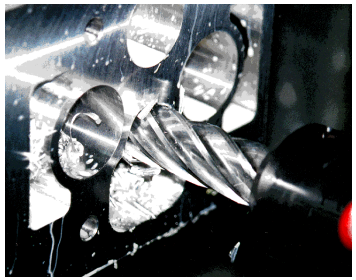
To NC Simulation

Results Before Committing to the Shop Floor

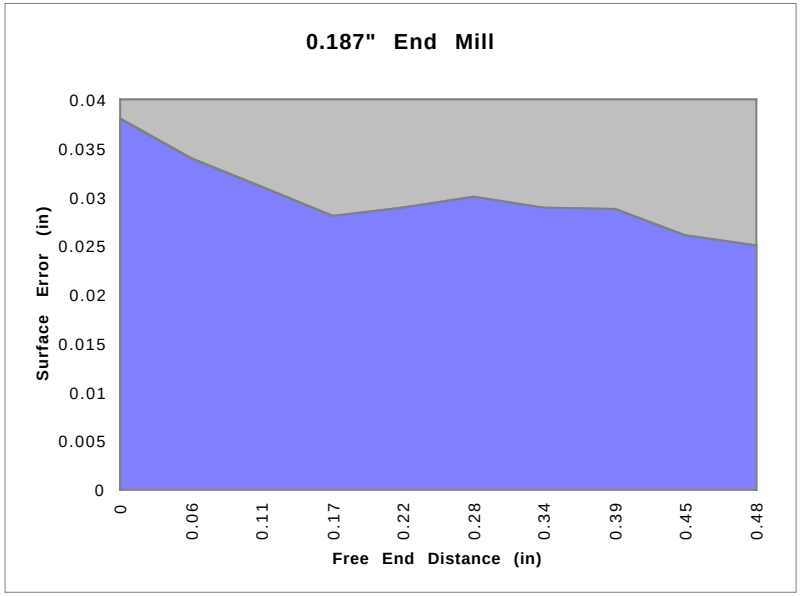
- Detailed analysis of surface error from face milling operations on top surface
- Evaluate alternative fixture designs to reduce surface error
  - i.e. 3-2-1 fixture or 4 clamp fixture designs
- Investigate alternative process plans (speeds and feeds, cutting tools)

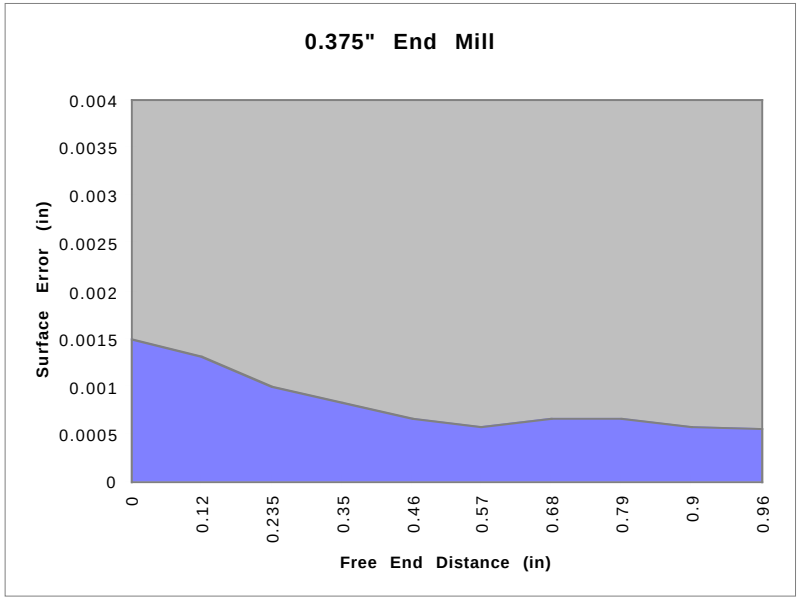
End Milling Simulations

- **Detailed analysis of surface error from end milling operation in multi-step pocket**
- **EMSIM analysis via the Internet**
- **Results used in product and process tradeoff**



Wall Surface Error Due to End Mill Deflection

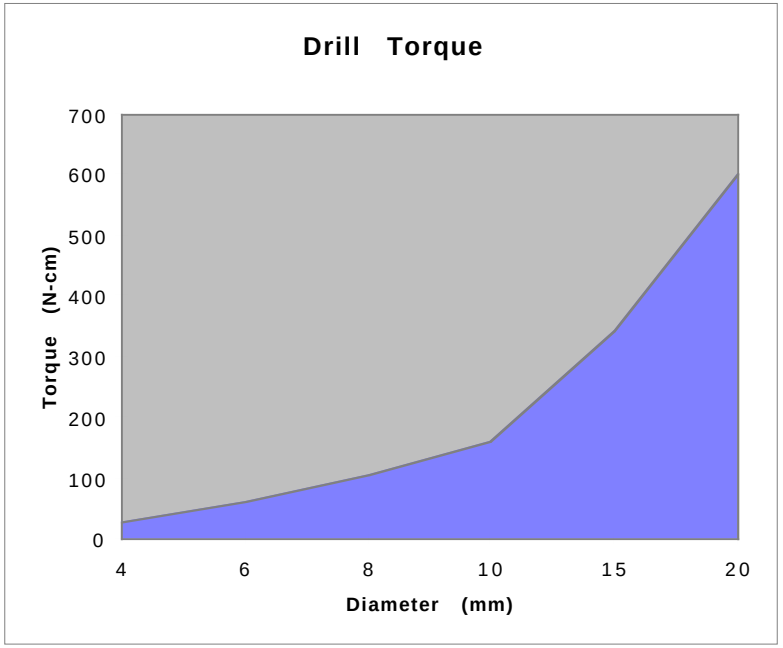


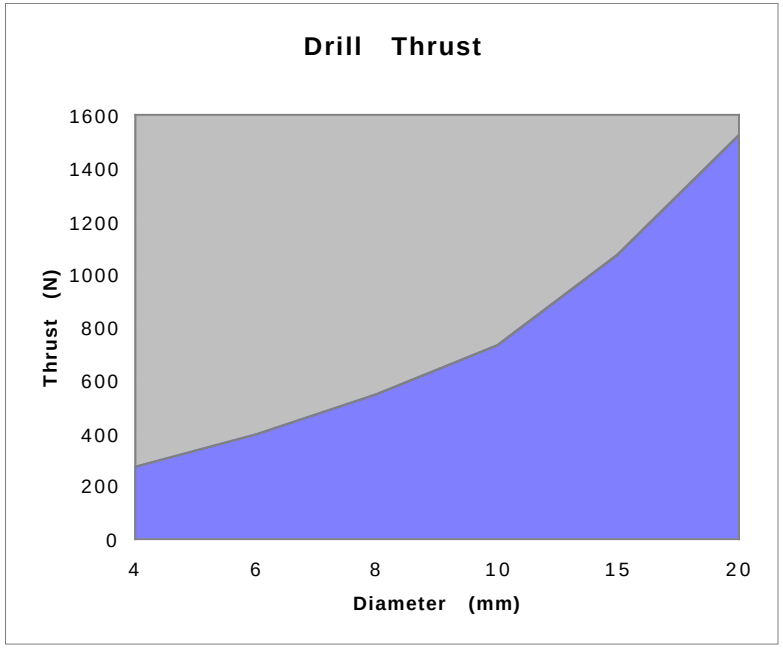


Larger diameter end mill reduces surface error, but affects product

Drilling Simulations

- **Analysis of drill torque and thrust during drilling operation in metering hole**
- **Investigated range of hole diameters from 4 - 20 mm**





Process Simulations used for Global Tradeoff